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(54) **METHOD FOR CONTROLLING OF VALVE TIMING OF CONTINUOUS VARIABLE VALVE DURATION ENGINE**

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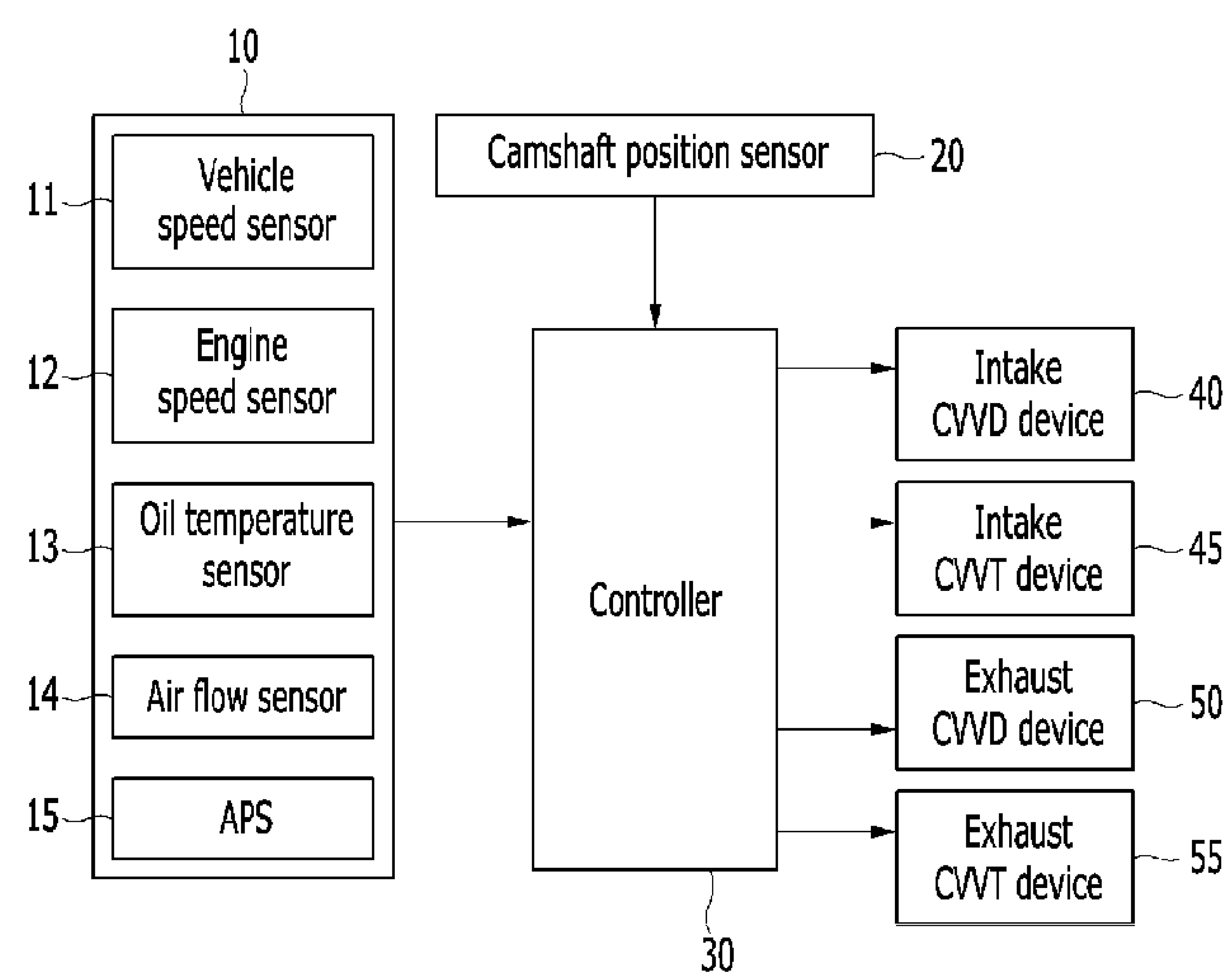
(57) **ABSTRACT**

A method for controlling valve timing of an engine may include: classifying control regions; applying a maximum duration to an intake valve and controlling a valve overlap in a first control region; applying the maximum duration to the intake valve and an exhaust valve in a second control region; controlling a manifold absolute pressure (MAP) of an intake manifold to be maintained constant in a third control region; controlling a wide open throttle valve (WOT) and creating a valve overlap by reducing interference of exhaust in a fourth control region; and controlling a wide open throttle valve (WOT) and controlling an intake valve closing timing based on the engine speed. In particular, the control regions are classified by a controller based on an engine load and an engine speed compared with predetermined values, respectively.

16 Claims, 4 Drawing Sheets



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F01L 13/00	(2006.01)
F01L 1/34	(2006.01)
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See application file for complete search history.

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FIG. 1

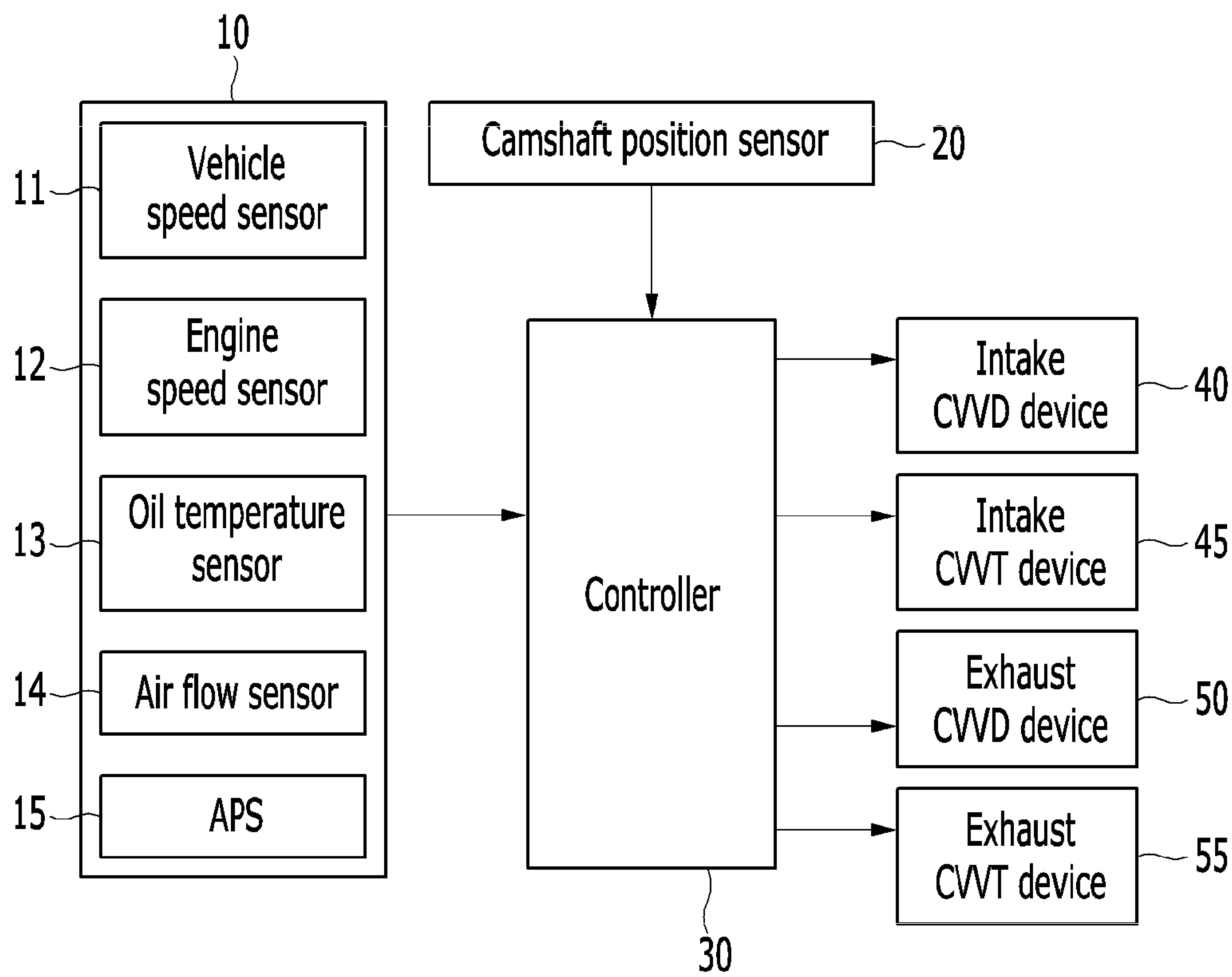

10
11
Vehicle speed sensor
12
Engine speed sensor
13
Oil temperature sensor
14
Air flow sensor
15
APS
Camshaft position sensor
20
Controller
30
Intake CVVD device
40
Intake CVVT device
45
Exhaust CVVD device
50
Exhaust CVVT device
55

FIG. 2

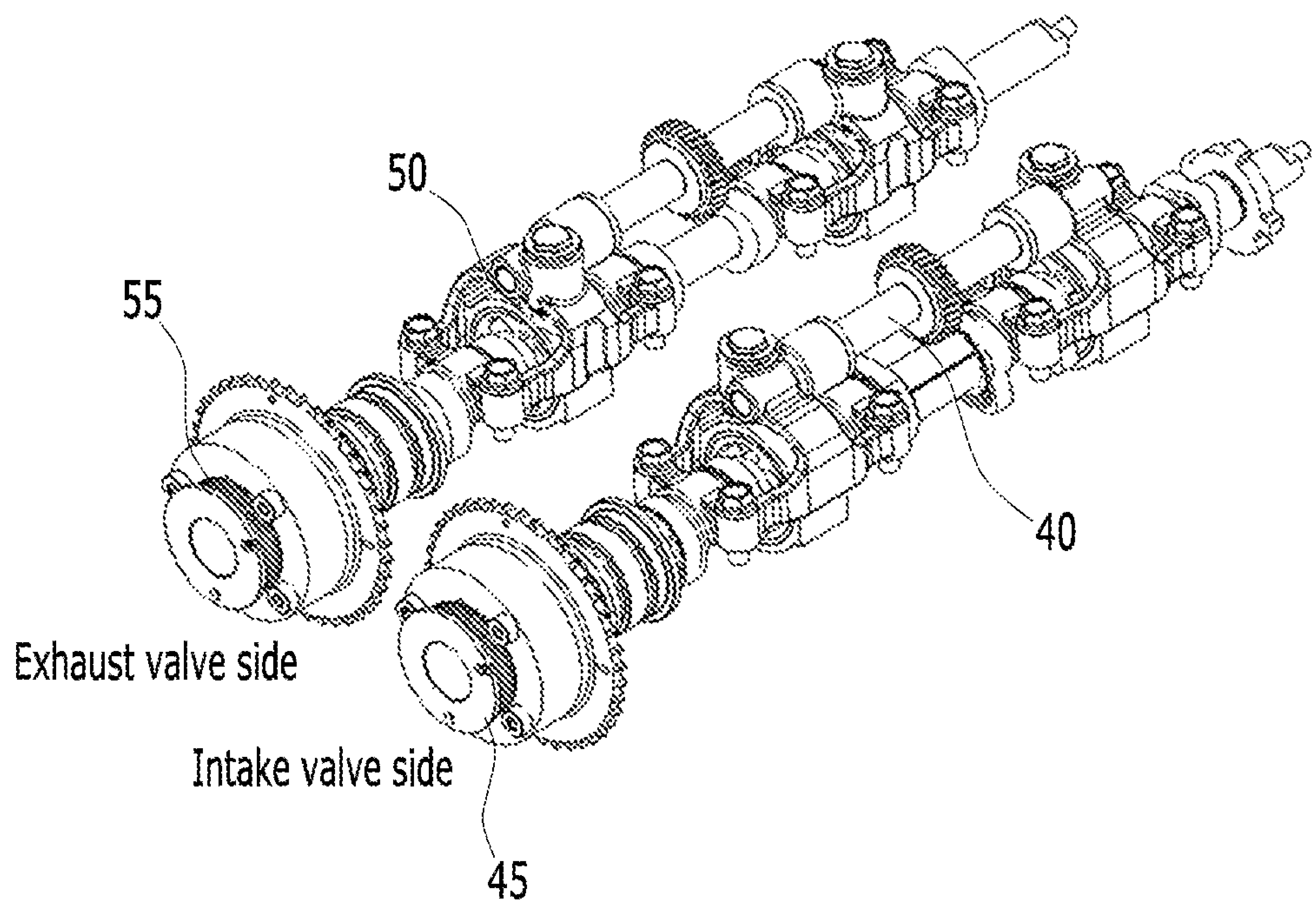
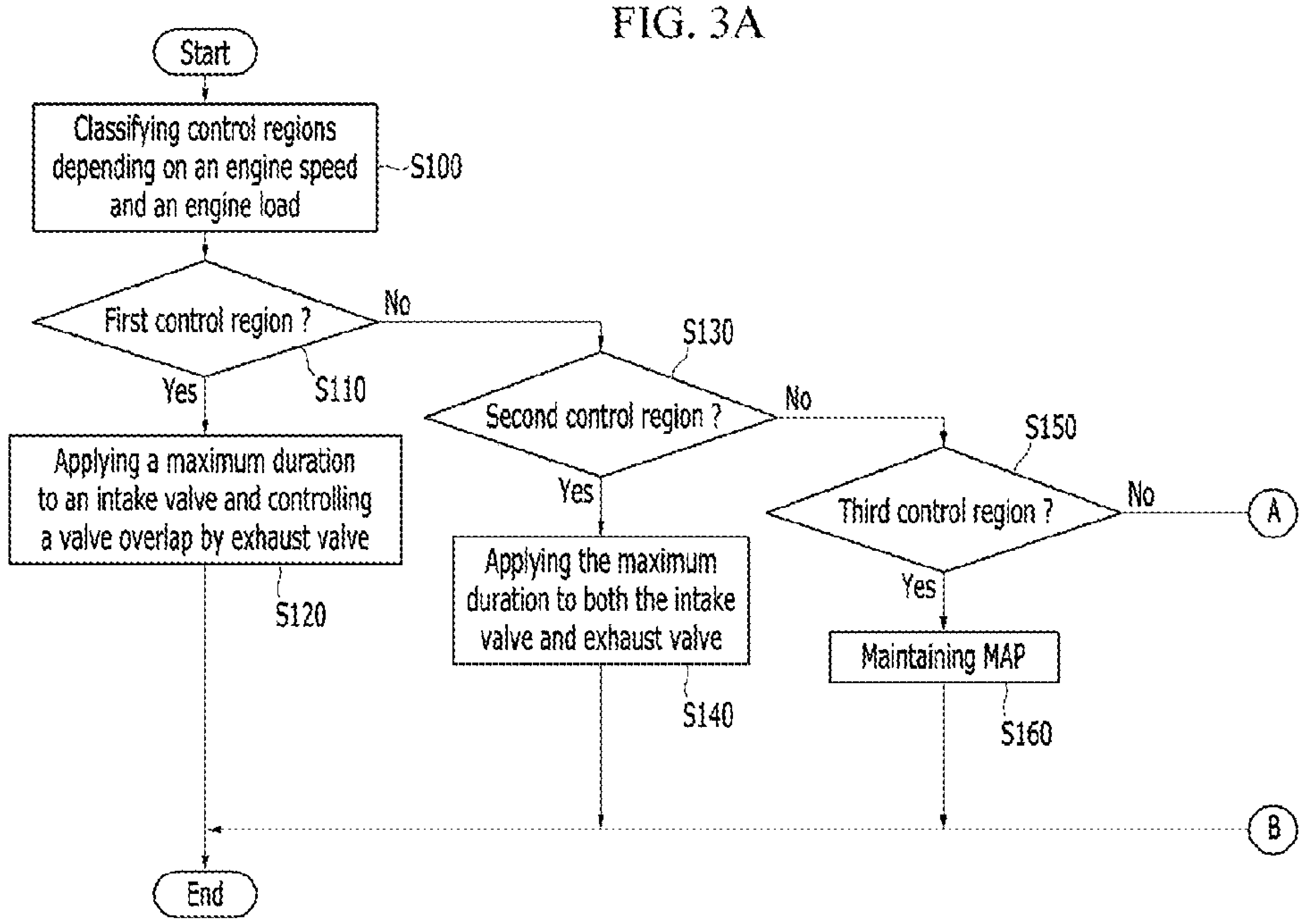
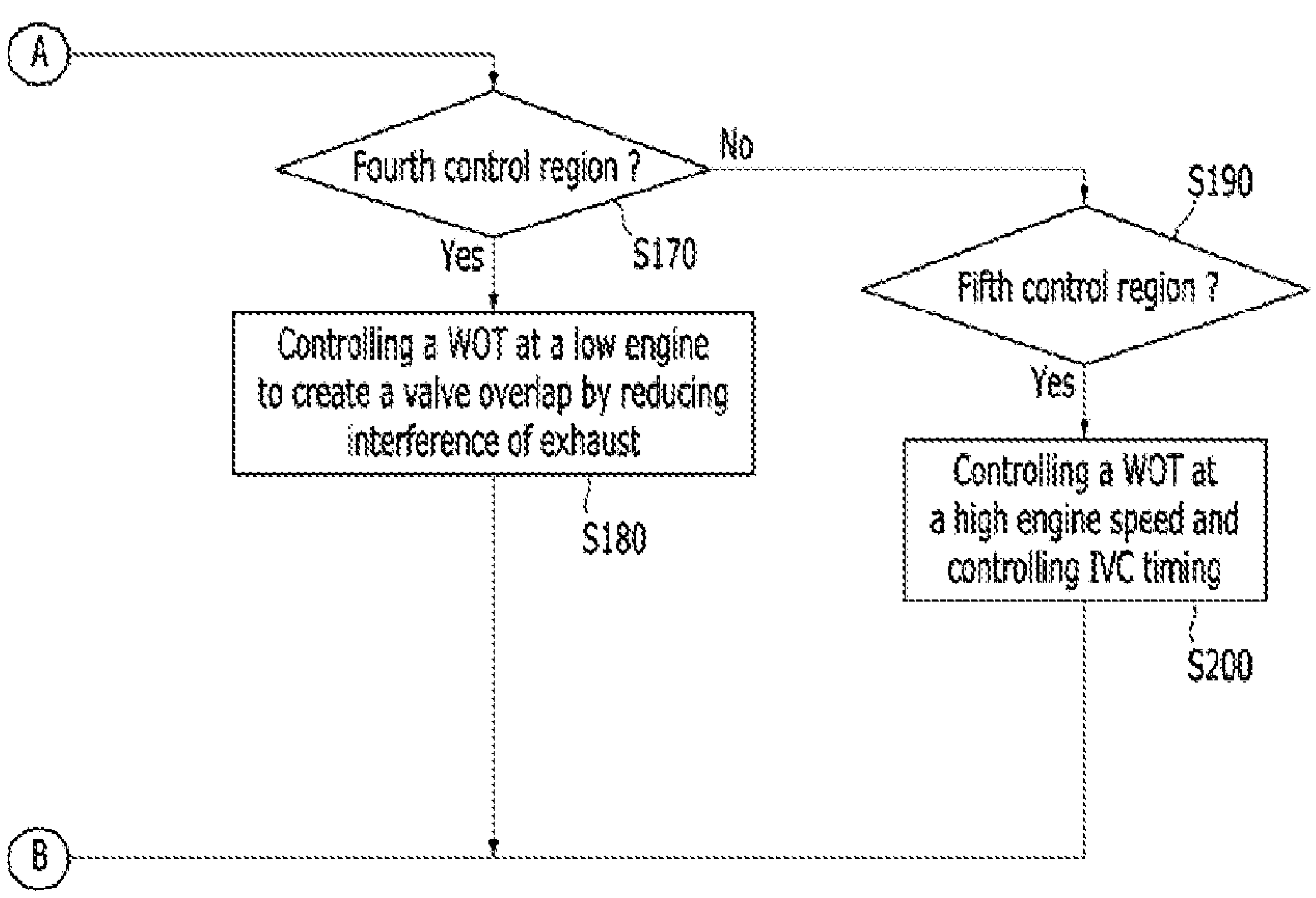


FIG. 3A



Start
Classifying control regions depending on an engine speed and an engine load
S100
First control region ?
No
Yes
S110
Applying a maximum duration to an intake valve and controlling a valve overlap by exhaust valve
S120
S130
Second control region ?
No
Yes
Applying the maximum duration to both the intake valve and exhaust valve
S140
S150
Third control region ?
No
A
Yes
Maintaining MAP
S160
B
End

FIG. 3B



A
Fourth control region ?
No
Yes
S170
Controlling a WOT at a low engine to create a valve overlap by reducing interference of exhaust
S180
S190
Fifth control region ?
Yes
Controlling a WOT at a high engine speed and controlling IVC timing
S200
B

FIG. 4A

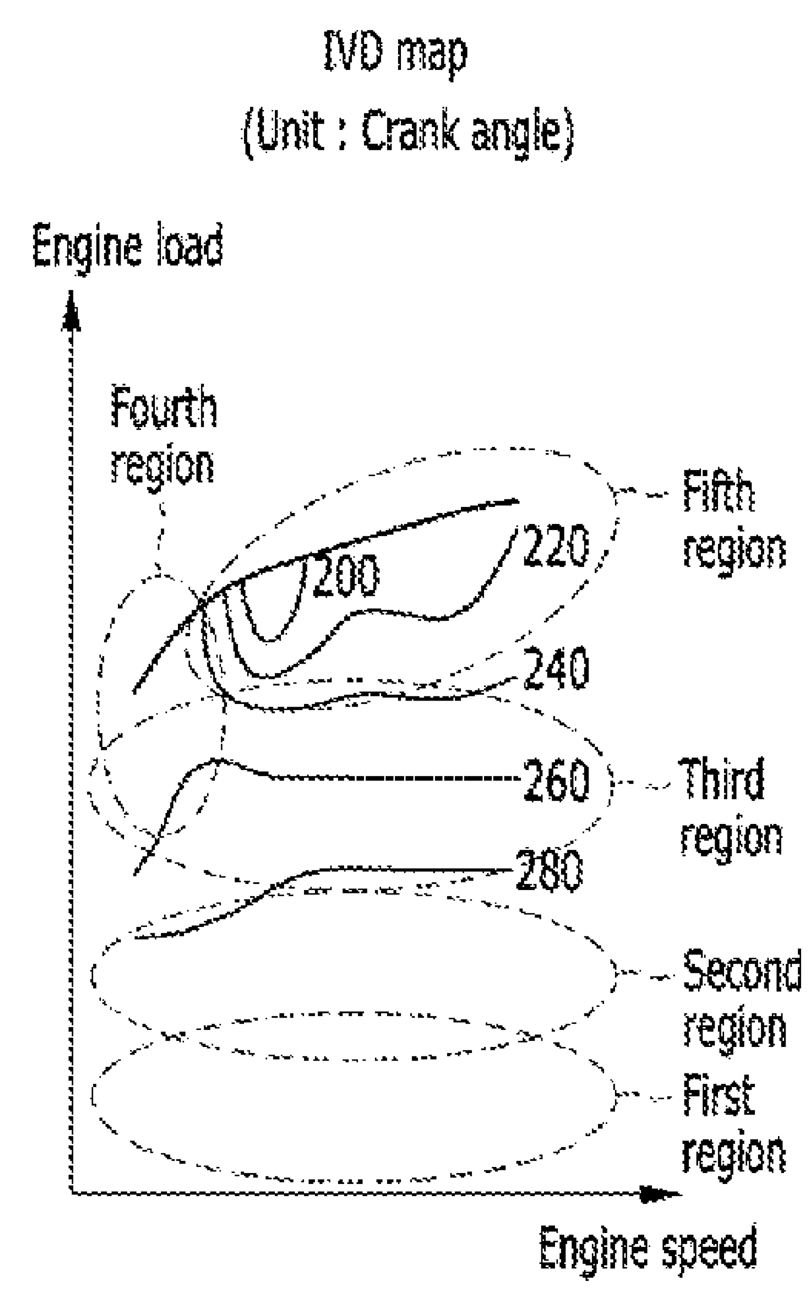


FIG. 4B

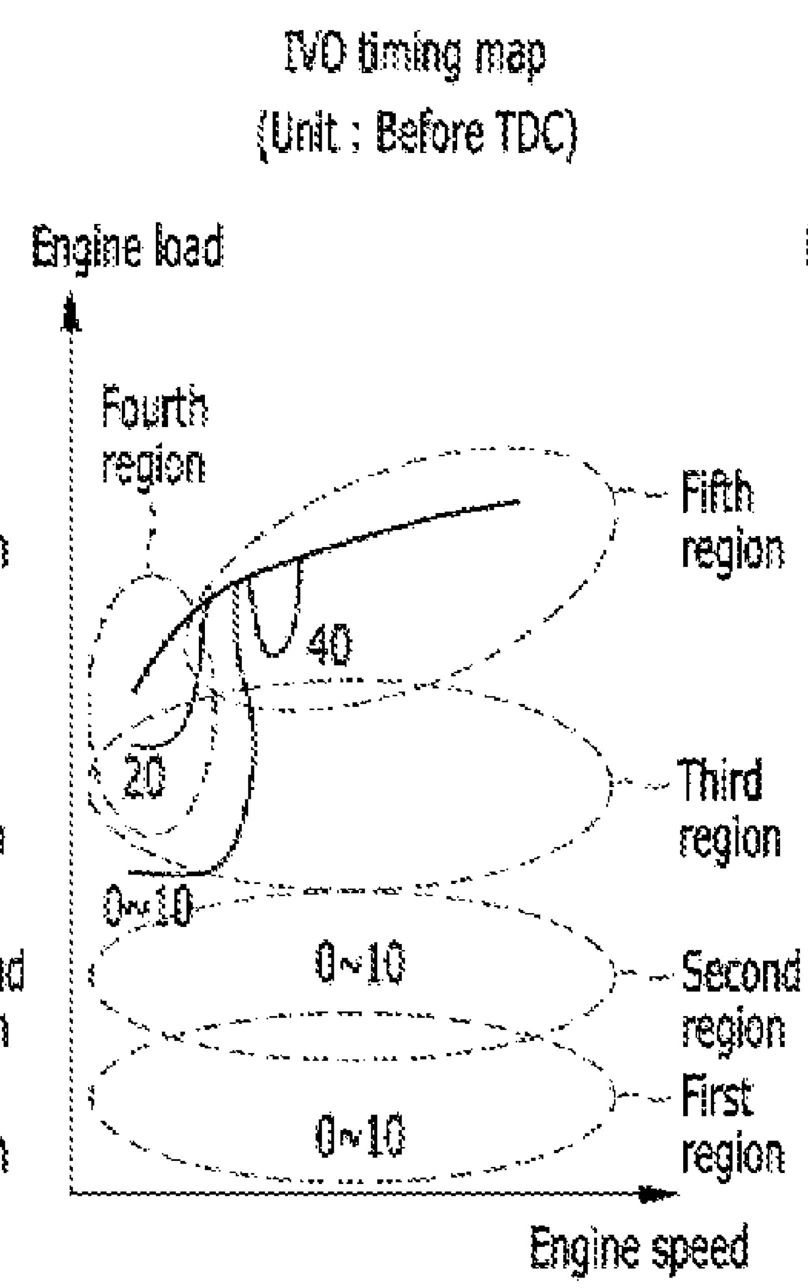


FIG. 4C

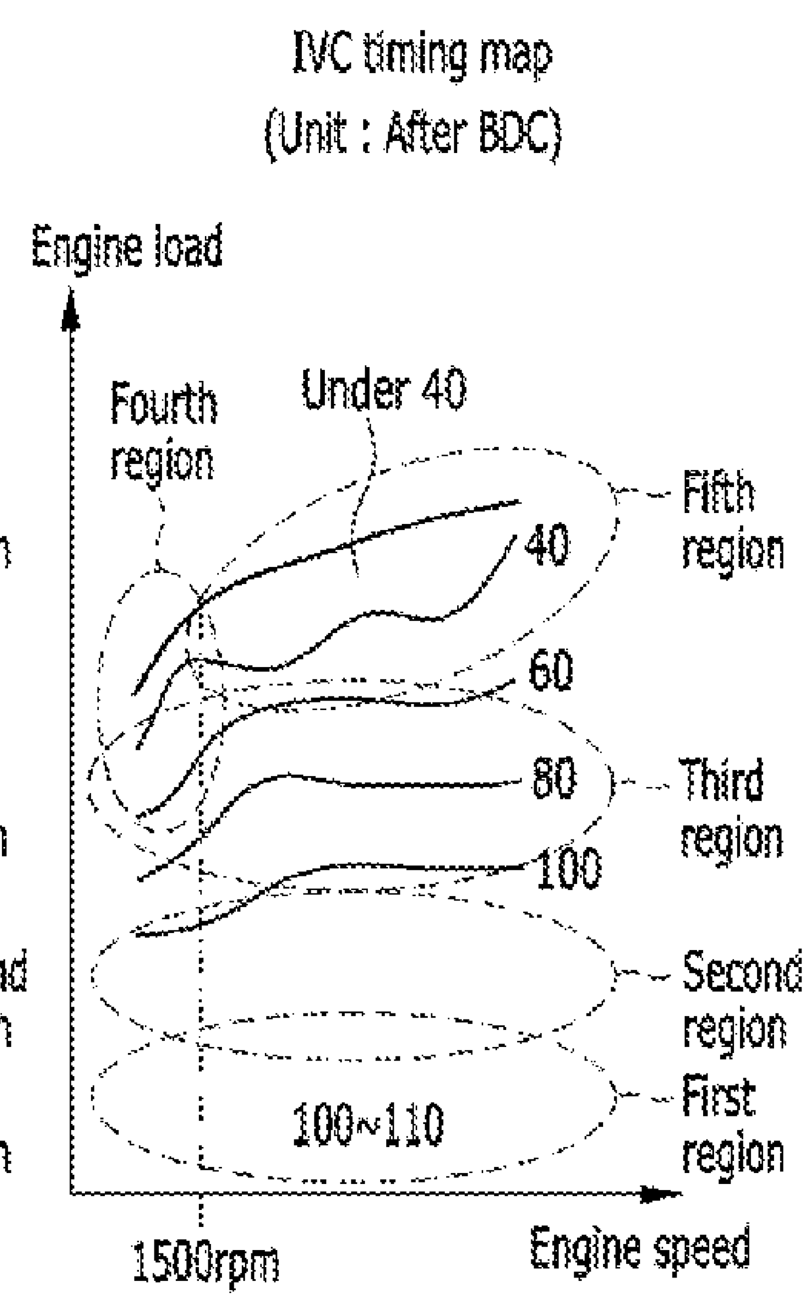


FIG. 5A

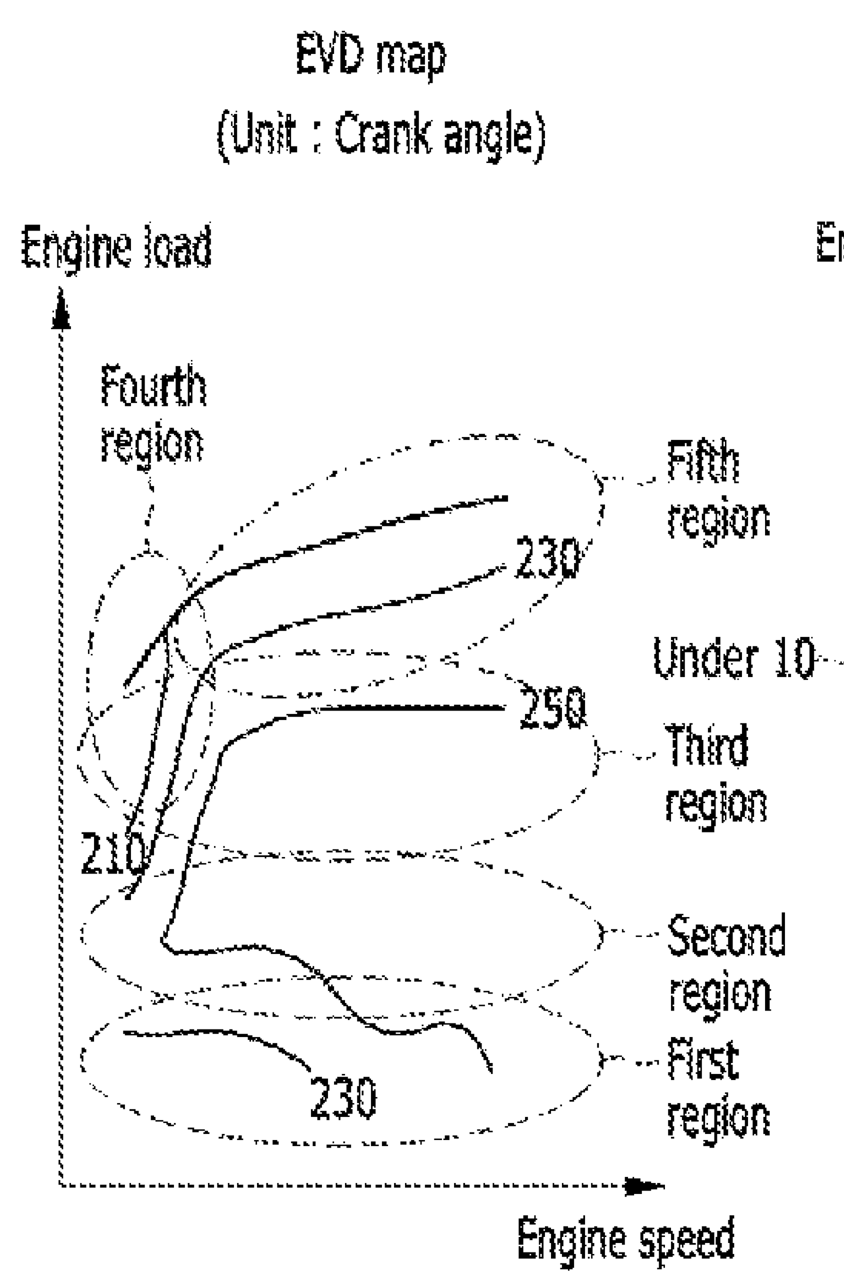


FIG. 5B

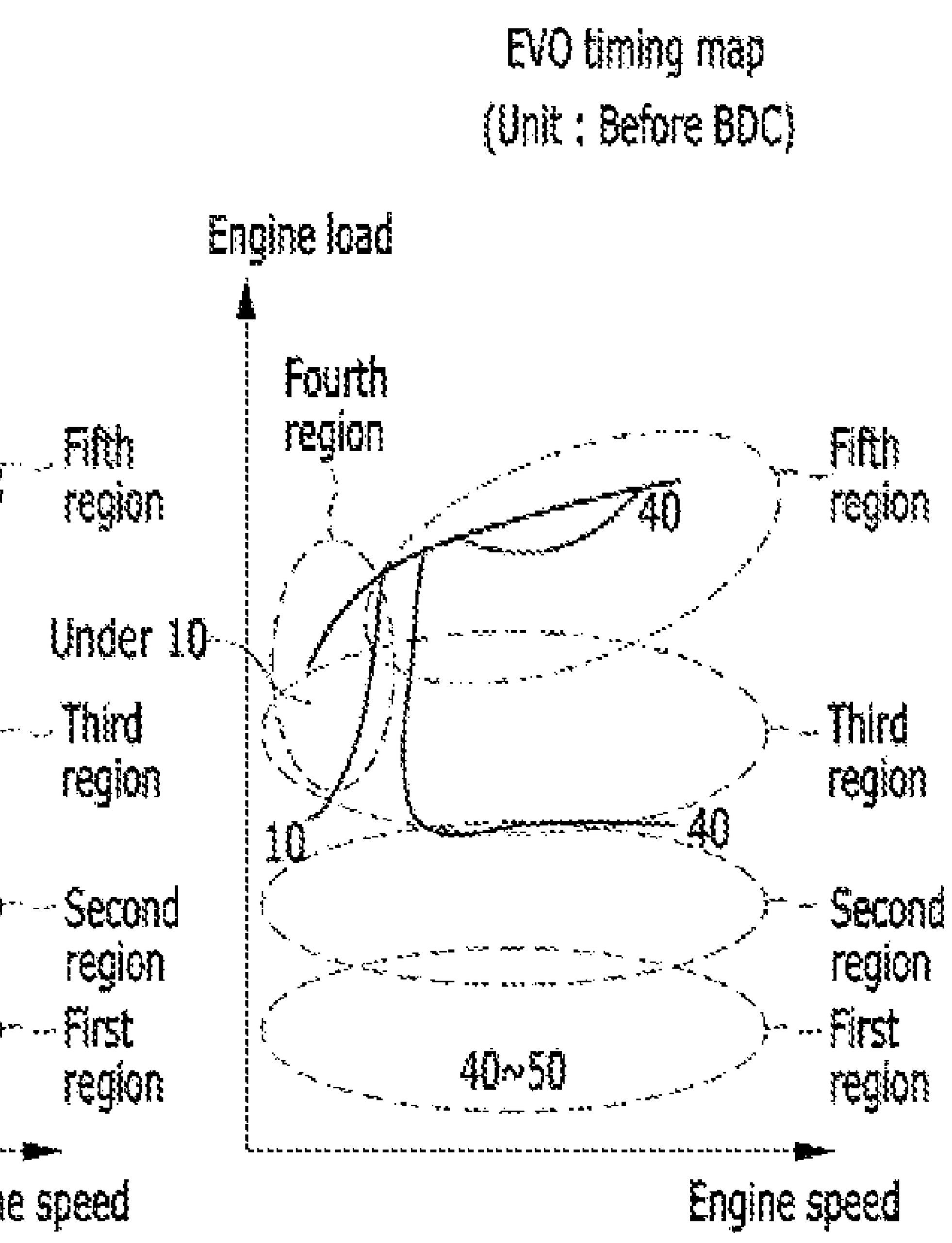
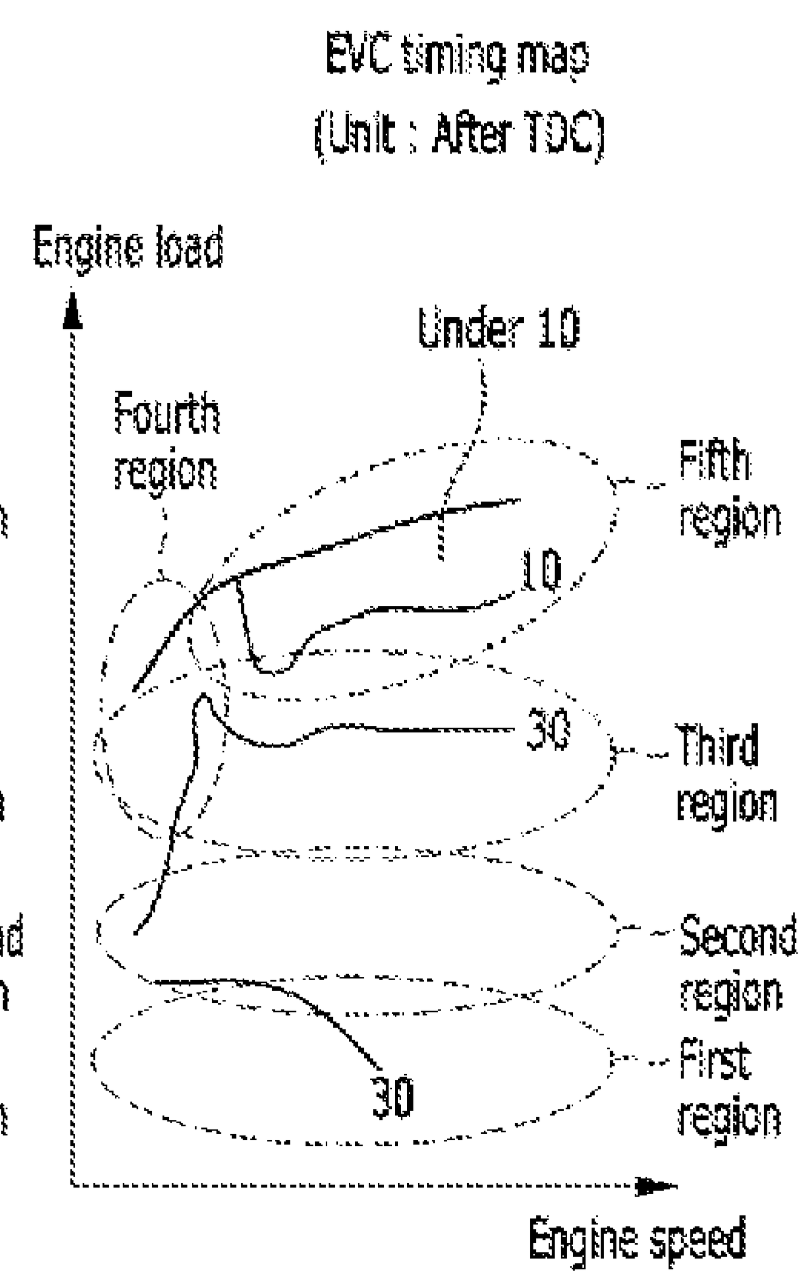


FIG. 5C



METHOD FOR CONTROLLING OF VALVE TIMING OF CONTINUOUS VARIABLE VALVE DURATION ENGINE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2015-0175139, filed on Dec. 9, 2015, the entire contents of which are incorporated herein by reference.

FIELD

The present disclosure relates to a system and a method for controlling valve timing of a continuous variable valve duration engine.

BACKGROUND

The statements in this section merely provide background information related to the present disclosure and may not constitute prior art.

An internal combustion engine combusts mixed gas in which fuel and air are mixed at a predetermined ratio through a set ignition mode to generate power by using explosion pressure.

Generally, a camshaft is driven by a timing belt connected with a crankshaft that converts linear motion of a cylinder by the explosion pressure into rotating motion to actuate an intake valve and an exhaust valve, and while the intake valve is opened, air is suctioned into a combustion chamber, and while an exhaust valve is opened, gas which is combusted in the combustion chamber is exhausted.

To improve the operations of the intake valve and the exhaust valve and thereby improve engine performance, a valve lift and a valve opening/closing time (timing) may be controlled according to a rotational speed or load of an engine. Therefore, a continuous variable valve duration (CVVD) device controlling the opening duration of an intake valve and an exhaust valve of the engine and a continuous variable valve timing (CVVT) device controlling the opening and closing timing of the intake valve and the exhaust valve of the engine have been developed.

The CVVD device may control opening duration of the valve. In addition, the CVVT device may advance or retard the opening or closing timing of the valve in a state that the opening duration of the valve is fixed. That is, if the opening timing of the valve is determined, the closing timing is automatically determined according to the opening duration of the valve.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the present disclosure and therefore it may contain information that does not form the prior art that is already known to a person of ordinary skill in the art.

SUMMARY

The present disclosure provides a system and a method for controlling valve timing of a continuous variable valve duration engine that simultaneously controls duration and timing of the valve being equipped with a continuous variable duration device and a continuous variable valve timing device disposed on intake valve side and exhaust valve side by independently controlling an opening and closing timing of an intake valve and an exhaust valve.

A method for controlling valve timing of engine provided with both a continuous variable duration (CVVD) device and a continuous variable valve timing (CVVT) device at intake valve and exhaust valve sides respectively according to one form of the present disclosure may include: classifying by a controller a plurality of control regions depending on an engine speed and an engine load, and wherein the a plurality of control regions may include a first control region when the engine load is less than a first predetermined load, a second control region when the engine load is greater than or equal to the first predetermined load and less than a second predetermined load, a third control region when the engine load is greater than or equal to the second predetermined load and less than a third predetermined load, a fourth control region when the engine load is greater than or equal to the second predetermined load and the engine speed is less than a predetermined speed, and a fifth control region when the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed; applying a maximum duration to the intake valve and exhaust valve in the second control region; controlling a manifold absolute pressure (MAP) of an intake manifold to be maintained constantly in the third control region; controlling a wide open throttle valve (WOT) and creating a valve overlap by reducing interference of exhaust in the fourth control region; and controlling a wide open throttle valve (WOT) and controlling an intake valve closing timing in accordance with the engine speed.

If the control region is in the first control region, then the controller may control an intake valve opening (IVO) timing, the intake valve closing (IVC) timing, and an exhaust valve opening (EVO) to be fixed and controls an exhaust valve closing (EVC) timing to be set up at a maximum value within sustainable combust stability.

If the control region is in the second control region, then the controller may control an exhaust valve closing (EVC) timing to be late as the engine load is increased in order that the exhaust valve reaches the maximum duration.

If the control region is in the third control region, then the controller may advance both an exhaust valve closing (EVC) timing and the intake valve closing (IVC) timing in order to maintain the MAP consistently when the engine load is increased.

If the control region is in the fourth region, then the controller may control an exhaust valve closing (EVC) timing to after a top dead center and control an intake valve opening (IVO) timing to before the top dead center to generate valve overlap.

If the control region is in the fourth region, then the controller may control an exhaust valve opening (EVO) timing close to a bottom dead center so as to reduce exhaust interference.

If the control region is in the fifth region, then the controller may retard an intake valve opening (IVO) timing and the intake valve closing (IVC) timing so as to increase an intake duration.

If the control region is in the fifth region, then the controller may control an exhaust valve opening (EVO) timing to before a bottom dead center to inhibit or prevent from generating the valve overlap and control an exhaust valve closing (EVC) timing close to a top dead center.

A system for controlling valve timing of a continuous variable valve duration engine according to another form of the present disclosure may include: a data detector detecting data related to a running state of the vehicle; a camshaft position sensor detecting a position of a camshaft; an intake continuous variable valve duration (CVVD) device controlling an opening time of an intake valve of the engine; an exhaust continuous variable valve duration (CVVD) device controlling an opening time of an exhaust valve of the engine; an intake continuous variable valve timing (CVVT) device controlling an opening and closing timing of the intake valve of the engine; an exhaust continuous variable valve timing (CVVT) device controlling an opening and closing timing of the exhaust valve of the engine; and a controller configured to classify a plurality of control regions depending on an engine speed and an engine load based on signals from the data detector and camshaft position sensor and configured to control the intake CVVD device, the exhaust CVVD device, the intake CVVT, and the exhaust CVVT device according to the control region, wherein the the plurality of control regions may include: a first control region when the engine load is less than a first predetermined load; a second control region when the engine load is greater than or equal to the first predetermined load and less than a second predetermined load; a third control region when the engine load is greater than or equal to the second predetermined load and less than a third predetermined load; a fourth control region when the engine load is greater than or equal to the second predetermined load and the engine speed is less than a predetermined speed; and a fifth control region when the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed, wherein the controller applies a maximum duration to the intake valve, controls a valve overlap by using the exhaust valve in the first control region, applies the maximum duration to the intake and exhaust valves in the second control region, controls a manifold absolute pressure (MAP) in an intake manifold to be maintained consistently in the third control region, controls a wide open throttle valve (WOT) and creates the valve overlap by reducing an exhaust interference in the fourth control region, and controls the wide open throttle valve (WOT) and controls an intake valve closing (IVC) timing in accordance with the engine speed in the fifth control region.

The controller may control an intake valve opening (IVO) timing, the intake valve closing (IVC) timing, and an exhaust valve opening (EVO) to be fixed and an exhaust valve closing (EVC) timing to be set up at a maximum value within sustainable combust stability in the first control region.

The controller may control an exhaust valve closing (EVC) timing to be late as the engine load is increased in order that the exhaust valve reaches the maximum duration in the second control region.

The controller may advance both an exhaust valve closing (EVC) timing and the intake valve closing (IVC) timing in order to maintain the MAP consistently when the engine load is increased in the third control region.

The controller may control an exhaust valve closing (EVC) timing to after a top dead center and controls an intake valve opening (IVO) timing to before the top dead center to generate valve overlap in the fourth control region.

The controller may control an exhaust valve opening (EVO) timing close to a bottom dead center so as to reduce exhaust interference in the fourth control region.

The controller may retard both an intake valve opening (IVO) timing and the intake valve closing (IVC) timing so as to increase an intake duration in the fifth control region.

The controller may control an exhaust valve opening (EVO) timing to before a bottom dead center to inhibit or prevent from generating the valve overlap and control an exhaust valve closing (EVC) timing close to a top dead center in the fifth control region.

As described above, according to one form of the present disclosure, duration and timing of the continuous variable valve are simultaneously controlled, so the engine may be controlled under desirable conditions.

That is, since opening timing and closing timing of the intake valve and the exhaust valve are appropriately controlled, thereby improving fuel efficiency under a partial load condition and engine performance under a high load condition.

In addition, a starting fuel amount may be reduced by increasing a valid compression ratio, and exhaust gas may be reduced by shortening time for heating a catalyst.

Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

In order that the disclosure may be well understood, there will now be described various forms thereof, given by way of example, references being made to the accompanying drawings, in which:

FIG. **1** is a schematic block diagram showing a system for controlling valve timing of a continuous variable valve duration engine;

FIG. **2** is a perspective view showing a continuous variable valve duration device and a continuous variable valve timing device which is disposed on intake valve and exhaust valve sides;

FIG. **3**A and FIG. **3**B are flowcharts showing a method for controlling valve timing of a continuous variable valve duration engine;

FIGS. **4**A-**4**C are graphs showing duration, opening timing, and closing timing of an intake valve depending on an engine load and an engine speed; and

FIGS. **5**A-**5**C are graphs showing duration, opening timing, and closing timing of an exhaust valve depending on an engine load and an engine speed.

The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

DETAILED DESCRIPTION

The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

As those skilled in the art would realize, the described forms may be modified in various different ways, all without departing from the spirit or scope of the present disclosure.

Throughout this specification and the claims which follow, unless explicitly described to the contrary, the word "comprise" and variations such as "comprises" or "comprising" will be understood to imply the inclusion of stated elements but not the exclusion of any other elements.

It is understood that the term "vehicle" or "vehicular" or other similar terms as used herein is inclusive of motor vehicles in general including hybrid vehicles, plug-in hybrid electric vehicles, and other alternative fuel vehicles (e.g., fuels derived from resources other than petroleum). As referred to herein, a hybrid electric vehicle is a vehicle that has two or more sources of power, for example a gasoline-powered and electric-powered vehicle.

Additionally, it is understood that some of the methods may be executed by at least one controller. The term controller refers to a hardware device that includes a memory and a processor configured to execute one or more steps that should be interpreted as its algorithmic structure. The memory is configured to store algorithmic steps, and the processor is specifically configured to execute said algorithmic steps to perform one or more processes which are described further below.

Furthermore, the control logic of the present disclosure may be embodied as non-transitory computer readable media on a computer readable medium containing executable program instructions executed by a processor, a controller, or the like. Examples of computer readable media include, but are not limited to, ROM, RAM, compact disc (CD)-ROMs, magnetic tapes, floppy disks, flash drives, smart cards, and optical data storage devices. The computer readable recording medium can also be distributed in network coupled computer systems so that the computer readable media is stored and executed in a distributed fashion, e.g., by a telematics server or a controller area network (CAN).

FIG. **1** is a schematic block diagram showing a system for controlling valve timing of a continuous variable valve duration engine according to one form of the present disclosure.

As shown in FIG. **1**, a system for controlling valve timing of a continuous variable valve duration engine includes: a data detector **10**, a camshaft position sensor **20**, a controller **30**, an intake continuous variable valve duration (CVVD) device **40**, an intake continuous variable valve timing (CVVT) device **45**, an exhaust continuous variable valve duration (CVVD) device **50**, and an exhaust continuous variable valve timing (CVVT) device **55**.

The data detector **10** detects data related to a running state of the vehicle for controlling the CVVD devices and the CVVT devices, and includes a vehicle speed sensor **11**, an engine speed sensor **12**, an oil temperature sensor **13**, an air flow sensor **14**, and an accelerator pedal position sensor **15**, although other sensors may be employed.

The vehicle speed sensor **11** detects a vehicle speed, transmits a corresponding signal to the controller **30**, and may be mounted at a wheel of the vehicle.

The engine speed sensor **12** detects a rotation speed of the engine from a change in phase of a crankshaft or camshaft, and transmits a corresponding signal to the controller **30**.

The oil temperature sensor (OTS) **13** detects temperature of oil flowing through an oil control valve (OCV), and transmits a corresponding signal to the controller **30**.

The oil temperature detected by the oil temperature sensor **13** may be determined by measuring a coolant temperature using a coolant temperature sensor mounted at a coolant passage of an intake manifold. Therefore, in one form, the oil temperature sensor **13** may include a coolant temperature sensor, and the oil temperature should be understood to include the coolant temperature.

The air flow sensor **14** detects an air amount drawn into the intake manifold, and transmits a corresponding signal to the controller **30**.

The accelerator pedal position sensor (APS) **15** detects a degree in which a driver pushes an accelerator pedal, and transmits a corresponding signal to the controller **30**. The position value of the accelerator pedal may be 100% when the accelerator pedal is pressed fully, and the position value of the accelerator pedal may be 0% when the accelerator pedal is not pressed at all.

A throttle valve position sensor (TPS) that is mounted on an intake passage may be used instead of the accelerator pedal position sensor **15**. Therefore, in one form, the accelerator pedal position sensor **15** may include a throttle valve position sensor, and the position value of the accelerator pedal should be understood to include an opening value of the throttle valve.

The camshaft position sensor **20** detects a change of a camshaft angle, and transmits a corresponding signal to the controller **30**.

FIG. **2** is a perspective view showing a continuous variable valve duration device and a continuous variable valve timing device which is disposed on intake valve and exhaust valve sides according to one form of the present disclosure.

As shown in FIG. **2**, the continuous variable valve duration device **40**, **50** and the continuous variable valve timing device **45**, **55** are mounted at the intake and exhaust valve sides.

The intake continuous variable valve duration (CVVD) device **40** controls an opening duration of an intake valve of the engine according to a signal from the controller **30**, the exhaust continuous variable valve duration (CVVD) device **50** controls an opening duration of an exhaust valve of the engine according to a signal from the controller **30**.

The intake continuous variable valve timing (CVVT) device **45** controls opening and closing timing of the intake valve of the engine according to a signal from the controller **30**, and the exhaust continuous variable valve timing (CVVT) device **55** controls opening and closing timing of the exhaust valve of the engine according to a signal from the controller **30**.

The controller **30** may classify a plurality of control regions depending on an engine speed and an engine load based on signals from the data detector **10** and camshaft position sensor **20**, and controls the intake CVVD and CVVT devices **40** and **45**, and the exhaust CVVD and CVVT devices **50** and **55** according to the control regions. Herein, the plurality of control regions may be classified into five regions.

The controller **30** applies a maximum duration to the intake valve and limits a valve overlap by using the exhaust valve in a first control region, applies the maximum duration to the intake and exhaust valves in a second control region, controls a manifold absolute pressure (MAP) in an intake manifold to be maintained consistently in a third control region, controls a wide open throttle valve (WOT) and creates the valve overlap by reducing an exhaust interference in a fourth control region, and controls a wide open throttle valve (WOT) and controls an intake valve closing (IVC) timing in accordance with the engine speed in a fifth control region.

For these purposes, the controller **30** may be implemented as at least one processor that is operated by a predetermined program, and the predetermined program may be programmed in order to perform each step of a method for controlling valve timing of a continuous variable valve duration engine according to one form of the present disclosure.

Various forms described herein may be implemented within a recording medium that may be read by a computer or a similar device by using software, hardware, or a combination thereof, for example.

The hardware of the forms described herein may be implemented by using at least one of application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, and electrical units designed to perform any other functions.

The software such as procedures and functions of the forms described in the present disclosure may be implemented by separate software modules. Each of the software modules may perform one or more functions and operations described in the present disclosure. A software code may be implemented by a software application written in an appropriate program language.

Hereinafter, a method for controlling valve timing of a continuous variable valve duration engine according to one form of the present disclosure will be described in detail with reference to FIG. **3**A to FIG. **5**C.

FIG. **3**A and FIG. **3**B are flowcharts showing a method for controlling valve timing of a continuous variable valve duration engine.

FIGS. **4**A-**4**C are graphs showing duration, opening timing, and closing timing of an intake valve depending on an engine load and an engine speed, and FIGS. **5**A-**5**C are graphs showing duration, opening timing, and closing timing of an exhaust valve depending on an engine load and an engine speed.

As shown in FIG. **3**A and FIG. **3**B, a method for controlling valve timing of a continuous variable valve duration engine according to the present disclosure starts with classifying a plurality of control regions depending on an engine speed and an engine load by the controller **30** at step S**100**.

The control regions will be described with reference to FIGS. **4**A-**4**C and FIGS. **5**A-**5**C. The first to sixth control regions are indicated in the FIGS. **4**A-**4**C and FIGS. **5**A-**5**C.

The controller **30** may classify control regions as a first control region when the engine load is less than a first predetermined load, a second control region when the engine load is greater than or equal to the first predetermined load and less than a second predetermined load, and a third control region when the engine load is greater than or equal to the second predetermined load and less than a third predetermined load. In addition, the controller **30** may classify control regions as a fourth region when the engine load is greater than or equal to the second predetermined load and the engine speed is less than a predetermined speed, a fifth region when the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed.

Meanwhile, referring the FIGS. **4**A to FIGS. **5**C, a crank angle is marked in an intake valve duration (IVD) map and an exhaust valve duration (EVD) map, which indicating the opening time of the intake valve and exhaust valve. For example, regarding the IVD map in the FIG. **4**A, a curved line written as a number **200** at inner side of the fifth region means that the crank angle is approximately 200 degrees, a curved lined marked as a number **220** at outer side of the number **200** means that the crank angle is approximately 220 degrees. Although not shown in the drawing, the crank angle which is more than approximately 200 less than about 220 is positioned between the curved line of the number **200** and the curved line of the number **220**.

In addition, a unit of number designated in an intake valve opening (IVO) timing map is before a top dead center (TDC), a unit of number designated in an intake valve close (IVC) timing map is after a bottom dead center (BDC), a unit of number designated in an exhaust valve opening (EVO) timing map is before BDC, and a unit of number designated in an exhaust valve closing (EVC) map is after TDC.

Each region and curved line in the FIGS. **4**A to FIG. **5**C are one form of the present disclosure, it may be modified within the technical idea and scope of the present disclosure.

Referring to the FIGS. **3**A to **5**C, the control regions are classified according to the engine speed and load in the step of S**100**. After that, the controller **30** determines whether the engine state is under the first control region at step S**110**.

In the step of S**110**, if the engine load is less than a first predetermined load, the controller **30** determines that the engine state is under the first control region. At this time, the controller **30** applies a maximum duration to the intake valve and controls the valve overlap between the exhaust valve and intake valve at step S**120**. The valve overlap is a state in which the intake valve is opened and the exhaust valve is not closed yet.

In other words, when the engine is under low load, then the controller **30** may control both the intake valve opening (IVO) timing and the intake valve close (IVC) timing being fixed such that the intake valve has a maximum duration value.

As shown in FIGS. **4**A-**4**C, the first control region may be approximately 0 to 10 degrees before TDC in the IVO timing map and approximately 100 to 110 degrees after BDC in the IVC timing map.

Also, the controller **30** may control the EVO timing to be fixed and set up the EVC timing. Meanwhile, as the valve overlap is increased, the fuel consumption is cut, whereas the combust stability is deteriorated. Accordingly, properly setting the valve overlap is desired. However, in another form of the present disclosure, it is possible to get highly improved fuel-efficiency by setting a desirable valve overlap up, which fixing the EVO timing and controlling the EVC timing to be set up at a maximum value within sustainable combust stability. The timing value may be determined by predetermined map.

For example, as shown in FIGS. **5**A-**5**C, the EVO timing may be fixed at approximately 40 to 50 degrees before BDC, the EVC timing may be established by moving the degrees thereof in an after TDC direction. The EVC timing may be a maximum value such that the combust stability is sustainable.

When the current engine state does not belong to the first control region at the step S**110**, the controller **30** determines whether the current engine state belongs to the second control region at step S**130**.

In the step of S**130**, if the engine load is more than or equal to the first predetermined load and less than the second predetermined load, the controller **30** determines that the engine state is under the second control region. At this time, the controller **30** controls both the intake valve and exhaust valve respectively having a maximum duration consistently at step S**140**.

The controller **30** may control the EVC timing to be late as the engine load is increased in order that the exhaust valve reaches the maximum duration.

Herein, the controller **30** fixes the IVO timing and IVC timing for applying the maximum duration to the intake valve in the first control region, thereby controller **30** may apply the maximum duration to the exhaust valve such that the difference between the atmospheric pressure and the pressure of the intake manifold is maintained at a predetermined value. For example, a manifold absolute pressure (MAP), which is the difference between atmospheric pressure and pressure of intake manifold, may be approximately 950 hPa.

When the current engine state does not belong to the second control region at the step S**130**, the controller **30** determines whether the current engine state belongs to the third control region at step S**150**.

In the step of S**150**, if the engine load is more than or equal to the second predetermined load and less than the third predetermined load, the controller **30** determines that the engine state is under the third control region. At this time, the controller **30** controls the MAP to be maintained consistently at step S**160**.

In other words, the controller **30** applies the maximum duration to the intake valve and the exhaust valve and controls the MAP to be maintained consistently in the second control region. And after, when the engine state is under the third control region as the engine load is increased, the controller **30** may advance both the EVC timing and IVC timing and controls the MAP to be maintained consistently.

Referring to the FIGS. **4**A to **5**C, the IVC timing and the EVC timing are advanced in the third region so as to maintain the MAP. In this case, if the EVC timing is advanced in a state that the IVO timing is fixed, then the valve overlap may be shorten, thereby the knocking may be decreased.

When the current engine state does not belong to the third control region at the step S**150**, the controller **30** determines whether the current engine state belongs to the fourth control region at step S**170**.

If the engine load is greater than or equal to the second predetermined load and the engine speed is less than predetermined speed in the S**170**, the controller **30** determines that the engine state is under the fourth control region. At this time, the controller **30** fully opens a throttle valve and controls to create valve overlap by reducing interference of exhaust at step S**180**.

In the fourth control region, the engine speed is less than the predetermined speed (e.g., approximately 1500 rpm) and back pressure is not high. Accordingly, it is desired to generate scavenging pressing combustion gas out by lowering pressure of exhaust port through reducing exhaust interference.

Therefore, the controller **30** controls IVO timing and EVC timing to create the valve overlap so as to generate the scavenging in the section of the valve overlap. In other words, as shown in FIGS. **4**A-**4**C, the controller **30** may control the IVO timing to before a top dead center, and may control EVC timing to after top dead center as shown in FIGS. **5**A-**5**C.

Further, the controller **30** may control the EVO timing to reduce exhaust interference. In other words, as shown in FIGS. **5**A-**5**C, as the EVC timing may be controlled to after a top dead center, the EVO timing may approach to the bottom dead center. Accordingly, short exhaust duration may be used in the fourth control region.

When the current engine state does not belong to the fourth control region at the step S**170**, the controller **30** determines whether the current engine state belongs to the fifth control region at step S**190**.

In the S**190**, if the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed, then the controller **30** determines that the engine state is under the fifth control region. At this time, the controller **30** fully opens a throttle valve and controls the IVC timing in accordance with the engine speed at step S**200**.

In other words, the controller **30** may retard the IVO timing and the IVC timing as the engine speed is increased such that the intake duration is prolonged. For example, since the IVC timing is most powerful element when the engine speed is greater than or equal to the predetermined speed (e.g., approximately 1500 rpm) in the fifth control region, the controller **30** may control the IVC timing as an optimal value based on the engine speed in one form of the present disclosure. Referring to the FIGS. **4**A-**4**C, the IVC timing may be gradually retarded from at an angle of approximately 20 degrees when the engine speed is less then predetermined speed (low speed) to at angle of approximately 60 degrees as the engine speed is increased.

At the same time, in the medium speed (e.g., approximately 1500-3000 rpm), the controller **30** may create valve underlap by retarding the IVO timing. Thereby, the intake duration may be decreased in a certain period, and after may be increased as the engine speed is increased.

In addition, the controller **30** may control the EVO timing to before the bottom dead center to inhibit or prevent from generating valve overlap and may control the EVC timing close to the top dead center.

As back pressure is increased, the scavenging generated in the fourth control region may be disappeared, thereby, it is not necessary to generate valve overlap. Accordingly, as shown in FIGS. **5**A-**5**C, the EVO timing may be an angle in a range of approximately 30-40 degrees before the bottom dead center favorable to pumping exhaust and the EVC timing may be close to the top dead center.

As described above, according to an exemplary form of the present disclosure, duration and timing of the continuous variable valve are simultaneously controlled, so the engine may be controlled under desirable conditions.

That is, since opening timing and closing timing of the intake valve and the exhaust valve are appropriately controlled, thereby improving fuel efficiency under a partial load condition and engine performance under a high load condition. In addition, a starting fuel amount may be reduced by increasing a valid compression ratio, and exhaust gas may be reduced by shortening time for heating a catalyst.

While this present disclosure has been described in connection with what is presently considered to be practical forms, it is to be understood that the present disclosure is not limited to the disclosed forms. On the contrary, it is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the present disclosure.

What is claimed is:

1. A method for controlling valve timing provided with both a continuous variable duration(CVVD) device and a continuous variable valve timing (CVVT) device at an intake valve side and an exhaust valve side respectively, the method comprising:

classifying, by a controller, a plurality of control regions depending on an engine speed and an engine load,

wherein the plurality of control regions comprises:

a first control region determined by the controller when the engine load is less than a first predetermined load,

a second control region determined by the controller when the engine load is greater than or equal to the first predetermined load and less than a second predetermined load,

a third control region determined by the controller when the engine load is greater than or equal to the second predetermined load and less than a third predetermined load,

a fourth control region determined by the controller when the engine load is greater than or equal to the second predetermined load and the engine speed is less than a predetermined speed, and

a fifth control region determined by the controller when the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed;

applying, by the controller, a maximum duration to an intake valve and controlling a valve overlap by using an exhaust valve in the first control region,

applying, by the controller, the maximum duration to the intake valve and exhaust valve in the second control region;

controlling, by the controller, a manifold absolute pressure (MAP) of an intake manifold to be maintained consistent in the third control region;

controlling, by the controller, a wide open throttle valve (WOT) and creating a valve overlap by reducing interference of exhaust in the fourth control region; and

controlling, by the controller, the wide open throttle valve (WOT) and controlling an intake valve closing timing (IVC) based on the engine speed.

2. The method of claim **1**, wherein when the first control region is determined, the controller controls an intake valve opening (IVO) timing, the intake valve closing (IVC) timing, and an exhaust valve opening (EVO) to be fixed, and controls an exhaust valve closing (EVC) timing to be set up at a maximum value within sustainable combust stability so as to limit a valve overlap.

3. The method of claim **1**, wherein when the second control region is determined, the controller controls an exhaust valve closing (EVC) timing to be late as the engine load is increased so that the exhaust valve reaches the maximum duration.

4. The method of claim **1**, wherein when the third control region is determined, the controller advances both an exhaust valve closing (EVC) timing and the intake valve closing (IVC) timing so as to maintain the MAP consistent when the engine load is increased.

5. The method of claim **1**, wherein when the fourth region is determined, the controller controls an exhaust valve closing (EVC) timing to after a top dead center and controls an intake valve opening (IVO) timing to before the top dead center to generate a valve overlap.

6. The method of claim **1**, wherein when the fourth region is determined, the controller controls an exhaust valve opening (EVO) timing close to a bottom dead center so as to reduce exhaust interference.

7. The method of claim **1**, wherein when the fifth region is determined, the controller retards an intake valve opening (IVO) timing and the intake valve closing (IVC) timing so as to increase an intake duration.

8. The method of claim **1**, wherein when the fifth region is determined, the controller controls an exhaust valve opening (EVO) timing to before a bottom dead center to inhibit from generating the valve overlap and controls an exhaust valve closing (EVC) timing close to a top dead center.

9. A system for controlling valve timing of a continuous variable valve duration engine, the system comprising:

a data detector configured to detect data related to a running state of a vehicle;

a camshaft position sensor configured to detect a position of a camshaft;

an intake continuous variable valve duration (CVVD) device configured to control an opening time of an intake valve of the engine;

an exhaust continuous variable valve duration (CVVD) device configured to control an opening time of an exhaust valve of the engine;

an intake continuous variable valve timing (CVVT) device configured to control an opening timing and a closing timing of the intake valve of the engine;

an exhaust continuous variable valve timing (CVVT) device controlling an opening and closing timing of the exhaust valve of the engine; and

a controller configured to classify a plurality of control regions depending on an engine speed and an engine load based on signals from the data detector and camshaft position sensor, and configured to control the intake CVVD device, the exhaust CVVD device, the intake CVVT, and the exhaust CVVT device according to the plurality of control regions,

wherein the plurality of control regions comprises:

a first control region determined by the controller when the engine load is less than a first predetermined load;

a second control region determined by the controller when the engine load is greater than or equal to the first predetermined load and less than a second predetermined load;

a third control region determined by the controller when the engine load is greater than or equal to the second predetermined load and less than a third predetermined load;

a fourth control region determined by the controller when the engine load is greater than or equal to the second predetermined load and the engine speed is less than a predetermined speed; and

a fifth control region determined by the controller when the engine load is greater than or equal to the third predetermined load and the engine speed is greater than or equal to the predetermined speed, and

wherein the controller applies a maximum duration to the intake valve and controls a valve overlap by using the exhaust valve in the first control region, and the controller applies the maximum duration to the intake and exhaust valves in the second control region, controls a manifold absolute pressure (MAP) in an intake manifold to be maintained consistent in the third control region, controls a wide open throttle valve (WOT) and creates the valve overlap by reducing an exhaust interference in the fourth control region, and controls the wide open throttle valve (WOT) and controls an intake valve closing (IVC) timing based on the engine speed in the fifth control region.

10. The system of claim **9**, wherein the controller controls an intake valve opening (IVO) timing, the intake valve closing (IVC) timing, and an exhaust valve opening (EVO) to be fixed, and the controller controls an exhaust valve closing (EVC) timing to be set up at a maximum value within sustainable combust stability in the first control region.

11. The system of claim **9**, wherein the controller controls an exhaust valve closing (EVC) timing to be late as the engine load is increased such that the exhaust valve reaches the maximum duration in the second control region.

12. The system of claim **9**, wherein the controller advances both an exhaust valve closing (EVC) timing and the intake valve closing (IVC) timing so as to maintain the MAP consistent when the engine load is increased in the third control region.

13. The system of claim **9**, wherein the controller controls an exhaust valve closing (EVC) timing to after a top dead center and controls an intake valve opening (IVO) timing to before the top dead center to generate a valve overlap in the fourth control region.

14. The system of claim **9**, wherein the controller controls an exhaust valve opening (EVO) timing close to a bottom dead center so as to reduce exhaust interference in the fourth control region.

15. The system of claim **9**, wherein the controller retards both an intake valve opening (IVO) timing and the intake valve closing (IVC) timing so as to increase an intake duration in the fifth control region.

16. The system of claim **9**, wherein the controller controls an exhaust valve opening (EVO) timing to before a bottom dead center to inhibit from generating the valve overlap and controls an exhaust valve closing (EVC) timing close to a top dead center in the fifth control region.

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